Name _____Period _____

Making Water

Your Tasks (Mark these off as you go)

- ☐ Define key vocabulary
- ☐ Review Avogadro's law
- ☐ Explore the gas phase reaction between hydrogen and oxygen
- ☐ Analyze your results
- ☐ Interpret your results
- ☐ Receive credit for this lab

☐ Define key vocabulary

Avogadro's law

Molar volume

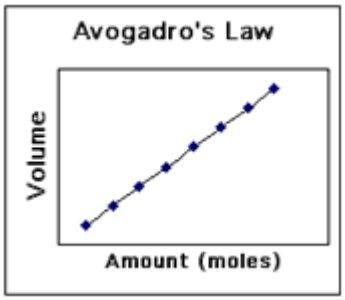
Partial pressure

Water vapor pressure

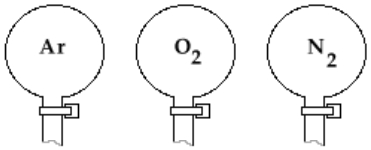
Mole fraction

☐ Review Avogadro's Law

Previously learned that the volume a gas occupies is directly proportional to the moles of gas. The relationship is shown below.



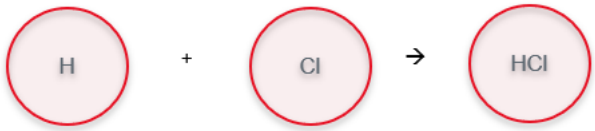
This relationship, also known as Avogadro's Law is true regardless of the identity of the gas. Avogadro also established that the actual volume 1 mole of gas occupies at Standard Temperature and Pressure (STP) is always equal to 22.4 L. This is summarized below,



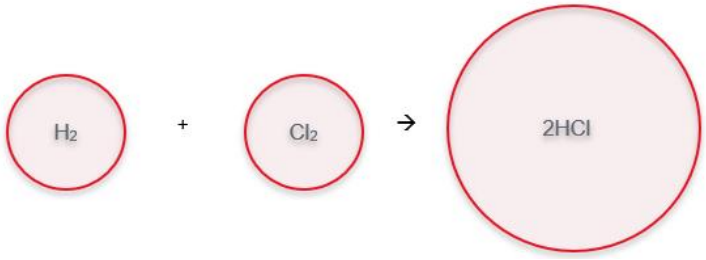
Volume:	22.4 L	22.4 L	22.4 L
Mass:	40 g	32 g	28 g
Quantity:	1 mol	1 mol	1 mol
Pressure:	1 atm	1 atm	1 atm
Temperature:	273 K	273 K	273 K

A flexible container holds 1 mole of H_2 gas and 1 mole of O_2 gas at STP. What is the volume of the container?

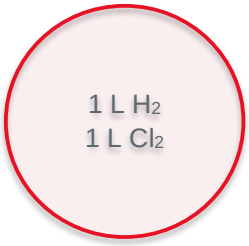
That fact that Avogadro's law is independent of the identity of the gas enabled scientist to study gas phase reactions. For example, consider the reaction between hydrogen gas and chlorine gas. According to the following reaction, if H_2 and Cl_2 were NOT diatomic molecules, 1 part hydrogen and 1 part chlorine would always produce 1 part HCl.



However, the fact that 1 part hydrogen gas and 1 part chlorine gas always resulted in 2 parts hydrochloric acid led scientists to conclude that both H_2 and Cl_2 were diatomic molecules. This is illustrated below,



The following gases are confined to a flexible container as shown,



A spark is used to ignite the mixture resulting in a reaction that produces HCl. Draw a picture to show what the contents in the container look like after the reaction is complete. What is the volume of the container after the reaction is complete?

Picture	**Volume after reaction is complete**

Draw a picture to show what the contents in the container look like after the reaction is complete for the following mixtures. Then indicate the volume of the container after the reaction is complete.

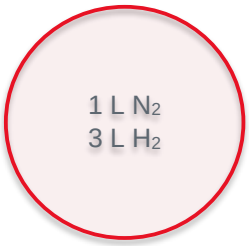
2 L H_2 and 1 L Cl_2

Picture	**Volume after reaction is complete**

1 L H_2 and 2 L Cl_2

Picture	**Volume after reaction is complete**

The following gases are confined to a flexible container as shown,



A spark is used to ignite the mixture resulting in a reaction that produces NH_3. Draw a picture to show what the contents in the container look like after the reaction is complete. What is the volume of the container after the reaction is complete?

Picture	**Volume after reaction is complete**

Draw a picture to show what the contents in the container look like after the reaction is complete for the following mixtures. Then indicate the volume of the container after the reaction is complete.

2 L N_2 and 3 L H_2

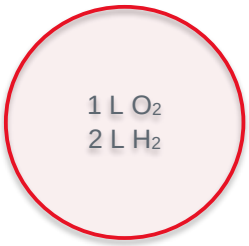
Picture	**Volume after reaction is complete**

3 L N_2 and 3 L H_2

Picture	**Volume after reaction is complete**

4 L N_2 and 3 L H_2	
Picture	**Volume after reaction is complete**

The following gases are confined to a flexible container as shown,



A spark is used to ignite the mixture resulting in a reaction that produces H_2O. Draw a picture to show what the contents in the container look like after the reaction is complete. What is the volume of the container after the reaction is complete?

Picture	**Volume after reaction is complete**

Draw a picture to show what the contents in the container look like after the reaction is complete for the following mixtures. Then indicate the volume of the container after the reaction is complete.

2 L O_2 and 2 L H_2	
Picture	**Volume after reaction is complete**

4 L O_2 and 2 L H_2	
Picture	**Volume after reaction is complete**

□ Explore the gas phase reaction between hydrogen and oxygen

The procedure below describes how you will collect different ratios of hydrogen gas and explore how they react.

Gas collection	
Label 3 flasks as follows. Flask 1: 1 part H_2 & 2 parts O_2 Flask 2: 1 part H_2 & 1 part O_2 Flask 3: 2 parts H_2 & 1 part O_2 Mark Flask 1 at the 100 mL and 50 mL lines Mark Flask 2 at the 75 mL line Mark Flask 3 at the 100 mL and 50 mL lines These marks will act as measuring points Fit the flasks with the correct stopper; keep the stoppers near the correct flask when completing the lab	
Partially fill a tray with water – record the temperature of the water in the data table Look up the atmospheric pressure and record this in the data table Navigate to the following link and locate the water vapor pressure at the temperature indicated and record the value in the data table Fill the flasks full of water and flip them into the tray so that you keep the flask full of water	

Obtain about 3 grams of Zn metal and keep in a weigh boat

Add the Zn metal to the <u>small</u> test tube, then place the test tube in the test tube rack.

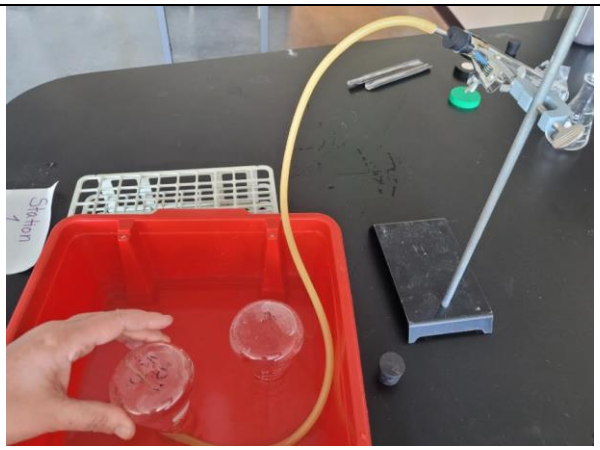
Fill the test tube about ¼ full with hydrochloric acid and stopper the test tube with the stopper/tubing apparatus

Allow some gas to escape to clear out the room air (N_2) in the rubber tubing

Put the rubber tubing under the lip of the flask that is UNDER water

- Fill flask 1 (1 part hydrogen/2 parts oxygen) with gas so that the water is displaced to the first line
- Fill flask 2 (1 part hydrogen/1 part oxygen) with gas so that the water is displaced to the 75 mL line
- Fill flask 3 (2 parts hydrogen/1 part oxygen) with gas so that the water is displaced to the second line

When the hydrogen has been collected keep the flasks inverted in the tub. Be careful to not tip them over.



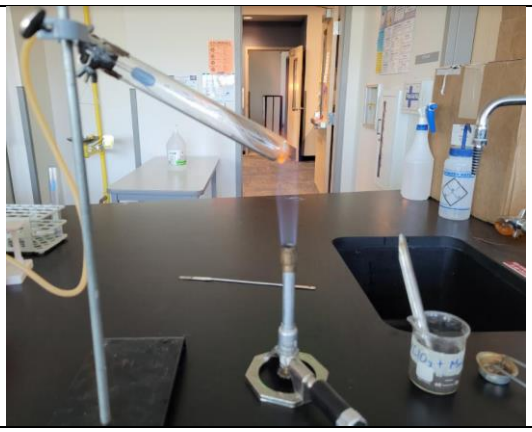
Obtain about 3 grams of potassium chlorate/manganese dioxide mixture ($KClO_3/MnO_2$) and add this to the <u>large</u> test tube.

Secure the test tube to the stand as shown in the diagram. It is important that the clamp is at the top of the tube, the tube is at a 45 degree angle, and the opening is pointed away from people.

Stopper the test with the stopper/tubing apparatus

Position the test tube about 6 inches above the Bunsen Burner

Light the Bunsen Burner and slide it under the test tube. Carefully heat your test tube. Keep the reaction under control by using a small to medium flame on the Bunsen burner.

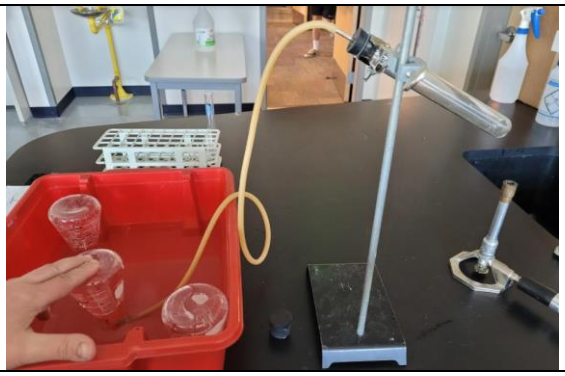


Allow some gas to escape to clear out the room air (N_2) in the rubber tubing

Put the rubber tubing under the lip of the flask that is UNDER water

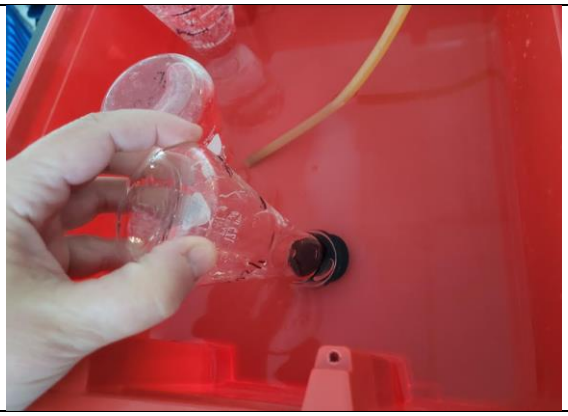
Displace ALL the remaining water in each flask.

Be careful – you do not want to keep the oxygen tubing in the flask for too long as you will push out the hydrogen



When all four flasks are completed, place each stopper in the tub and secure it to a flask while it is still inverted in the water.

Be careful – keep the lip of the flask under water or you will lose the gases you collected



Clean up

Once you have completed collecting your gases and the flasks have been stoppered, wipe down the table and wash your hands.

To clean up the hydrogen set up: bring the test tube with Zn and HCl to the fume hood and dump the contents in the designated beaker and rinse with a squirt bottle

To clean up the oxygen group: allow the test tube to completely cool to the touch, then use a spatula to chip out the solid that has hardened in the test tube. **DO NOT USE WATER** to clean the big test tube!

Testing your gas ratios

Wrap the first flask with a cloth and have someone else in your group hold it

Light a candle at your table to keep a flame to light the splint. When you are ready to test the gas, light the splint so that you have a good flame

Have the person holding the flask remove the stopper then IMMEDIATELY place the flame above the opening.

Record the loudness of the reaction in the data table below

Repeat with the remaining flasks

Data table

Flask	**Loudness (3 = loudest)**		
1	1	2	3
2	1	2	3
3	1	2	3
Water temperature			
Atmospheric pressure			
Vapor pressure of water			

□ Analyze your results

The gases you collected were collected over water. In addition to oxygen and hydrogen, what other gas was present in the flask?
Calculate the pressure of the dry gases in the flask.
Calculate the moles of water in the flask (use 150 mL as the total volume, use the water vapor pressure from you data table for the pressure)

Use pressure of the dry gas above to calculate the combined moles of hydrogen and oxygen.
Flask 1 contained 1 part hydrogen and 2 parts oxygen, Flask 2 contained 1 part hydrogen and 1 part oxygen, Flask 3 contained 2 parts hydrogen and 1 part oxygen. Based on these ratios, calculate the moles of hydrogen and oxygen in each flask.
Flask 1: Flask 2: Flask 3:

For each flask, calculate the mole fraction of hydrogen, oxygen, and water

Flask 1:

Flask 2:

Flask 3:

For each flask, calculate partial pressure of hydrogen, oxygen, and water. To do this, multiple the mole fraction of each component by the atmospheric pressure you recorded in your data table.

Flask 1:

Flask 2:

Flask 3:

□ Interpret your results

Answer the following in complete sentences. You must also be mindful of spelling, punctuation and overall writing quality.
What was the purpose of this experiment?
In your own words, summarize what you did to accomplish the purpose.
The formula for water is H_2O. Based on this formula, which flask should have resulted in the loudest reaction? Are your results consistent with this prediction? Why or why not?

□ Receive Credit for this lab

Each group member must complete and submit their own lab to receive credit